FINAL
ECOLOGICAL RISK ASSESSMENT

KRESS CREEK/WEST BRANCH DUPAGE RIVER SITE
SEWAGE TREATMENT PLANT SITE
West Chicago Illinois

Remedial Investigation / Feasibility Study Oversight

WA No. 216-RSBD-05ZZ/Contract No. 68-W6-0025

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Acronyms and Abbreviations

µg/L	micrograms per liter
AEC	Atomic Energy Commission
BAF	bioaccumulation factor
BCF	bioconcentration factor
BCG	biota concentration guide
COPC	constituent of potential concern
CSM	conceptual site model
DDT	dichlorodiphenyl trichloroethane
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
ERA	ecological risk assessment
HQ	hazard quotient
IAEA	International Atomic Energy Agency
IEPA	Illinois Environmental Protection Agency
KCK	Kress Creek
KM	Kerr-McGee
k_{oc}	organic carbon partition coefficient
k_{ow}	octanol-water partition coefficient
LD_{50}	lethal dose at 50% of the test population
LOAEL	lowest-observed adverse effect level
mg/kg	milligrams per kilogram
mg/kg-BW/day	milligrams per kilogram body weight of the receptor per day
mGy/d	milliGrays per day
mGy/h	milliGrays per hour
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	no-observed effect level

ORNL	Oak Ridge National Laboratory
p,p′-DDD	p,p′-dichlorodiphenyl dichloroethane
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
pCi/g	picoCuries per gram
Ra-226	radium-226
Ra-228	radium-228
RAD-BCG	DOE’s RAD-BCG model
REF	Rare Earths Facility
RI/FS	remedial investigation/feasibility study
SERA	screening ecological risk assessment
STP	Sewage Treatment Plant
SVOCs	semivolatile organic chemicals
TRV	toxicity reference value
USEPA	U.S. Environmental Protection Agency
WBDR	West Branch of the DuPage River

SECTION 1

Introduction

This screening ecological risk assessment (SERA) was conducted for the Kerr-McGee Sewage Treatment Plant (STP) and Kress Creek/West Branch of the DuPage River (KCK) Sites, DuPage County, West Chicago, Illinois. It follows methodology outlined in the USEPA's Superfund Risk Assessment Guidance (1997).

The National Contingency Plan (NCP) (Section 300.430 (d)(1)) requires that a risk assessment be performed as part of an Remedial Investigation/Feasibility Study (RI/FS). The primary purpose of the ecological risk assessment (ERA) is to provide risk managers with an understanding of the actual and potential risks to the environment posed by a site and any uncertainties associated with the assessment. This information may be useful in determining whether a current or potential threat to the environment exists that warrants remedial action (USEPA, 1990; 1991).

At the conclusion of the SERA, there are four possible decision points:

1. **No further action is warranted**. This decision is appropriate if the SERA indicates that sufficient data are available on which to base a conclusion of no unacceptable risk.

2. **Further evaluation is warranted**. This decision is appropriate if the SERA indicates that there is the potential for unacceptable risks for some pathways, receptors, and chemicals. In this instance, the ERA would progress to the baseline phase of the ERA process.

3. **Further data are required.** This decision is appropriate if the SERA indicates that there are insufficient data on which to base a risk estimate. This decision may also be appropriate if the potential for unacceptable risks is identified following the SERA and additional data to refine these estimates (e.g., additional analytical data, measures of bioavailability, etc.) are needed.

4. **Take remedial action**. This decision may be appropriate for circumstances in which the potential for unacceptable risks was identified following the SERA but these potential risks could best be addressed through remedial action (e.g., presumptive remedy, soil removal) rather than additional study.

Kress Creek (KCK) and the Sewage Treatment Plant (STP) are two of four sites in and around West Chicago, Illinois, that have been contaminated by materials generated and stored on the Kerr-McGee Rare Earths Facility (REF). This report presents the results of the SERA conducted for these two sites in light of the objectives presented above; media data collected in 1993 through 1995, and 1999 through 2001 were used to conduct this analysis. Additionally, the RI Report for the Kress Creek and STP Sites, prepared by BBL (2004) was used for project background information.

1.1 Report Organization

This report is divided into the following sections:

- **Section 1: Introduction.** Describes the purpose and scope of the SERA and outlines the report organization.
- **Section 2: Overview of the Ecological Risk Assessment Process.** Presents a brief discussion of the U.S. Environmental Protection Agency's (USEPA's) ecological risk assessment (ERA) approach.
- **Section 3: Screening Level Problem Formulation.** Describes the ecological setting of the site, including relevant transport pathways, receptors of concern, and the development of the conceptual site model (CSM).
- **Section 4. Screening Level Exposure Estimate and Risk Characterization.** Incorporates all of the qualitative and quantitative statements into one cohesive description of site risks and identifies the constituents of potential concern (COPCs).
- **Section 5. Uncertainty Assessment.** Identifies the sources of uncertainty in the SERA in the context of their potential impacts on the risk conclusions.
- **Section 6: Conclusions.** Presents the conclusions of this SERA.
- **Section 7: References.** Lists all references cited in the report.

Tables and figures are provided at the end of this document in respective sections.

1.2 Project Background

1.2.1 Kress Creek/West Branch of DuPage River Site

The Kress Creek site (KCK), located in DuPage County, Illinois, includes about 1.5 miles of Kress Creek and 5.2 miles of the West Branch DuPage River (WBDR), and contains contaminated sediments, banks, and/or floodplain areas. The site became contaminated by past surface water runoff from the REF that discharged into the creek via a storm sewer outfall located south of Roosevelt Road (Route 38), just east of the Elgin, Joliet, and Eastern railroad tracks. The KCK Site includes the creek from the storm sewer outfall to the creek's confluence with the WBDR, and the WBDR from the confluence to the McDowell Dam. The study area originally ended at the Warrenville Dam, but later was expanded further downstream to the McDowell Dam. See Figure 1-1.

1.2.2 Sewage Treatment Plant Site

The STP Site includes the West Chicago Sewage Treatment Plant (STP Upland), which is owned and operated by the City of West Chicago, and approximately 1.2 miles of the WBDR from the northern boundary of the STP property to the river's confluence with the creek (STP River). See Figure 1-1. The STP upland became contaminated from the use of thorium mill tailings as fill material. Kerr-McGee and the City of West Chicago conducted voluntary cleanup actions at the STP Upland during the mid-1980s (prior to the site's listing on the National Priorities List). The STP River has areas with contaminated sediments, banks and/or floodplains and became contaminated by runoff and erosion from contaminated areas of the STP Upland.

1.3 Site History

Detailed information on site history for the KCK and STP Sites is contained in the RI Report for the Kress Creek and STP Sites (BBL, 2004).

SECTION 2

Overview of the Ecological Risk Assessment Process

The USEPA (USEPA, 1997) has developed an 8-step process for conducting ERAs as follows:

- **Step 1:** Screening-Level Problem Formulation and Ecological Effects Evaluation
- **Step 2:** Screening-Level Exposure Estimate and Risk Calculation
- **Step 3:** Baseline Risk Assessment Problem Formulation
- **Step 4:** Study Design and Data Quality Objective Process
- **Step 5:** Field Verification of Sampling Design
- **Step 6:** Site Investigation
- **Step 7:** Risk Characterization
- **Step 8:** Risk Management

Steps 1 and 2 together constitute a SERA, the purpose of which is to determine the potential for risks based on conservative assumptions and methodologies. If such risks are possible, the results of the SERA are then used to focus subsequent steps of the ERA process (including the collection of any subsequent data) on the areas, chemicals, media, and receptors with the highest risk potential. Step 3 of the ERA process consists of a refined problem formulation and is the first step of the baseline ecological risk assessment (BERA). In Step 3, risk estimates are recalculated based on refined exposure assumptions, site-specific data, and/or detailed literature review. In Steps 4 through 6 of the process, methodologies for collecting and evaluating the data needed to answer these risk questions (test the hypotheses) are developed and the data are collected. These data are used to derive an estimate of potential risk (with an associated evaluation of the level of uncertainty of the estimate) in Step 7 using a weight-of-the-evidence type of approach relative to the assessment endpoints and risk questions. In Step 8, any identified risks are addressed through a risk management process. Each of these steps is conducted as the results of previous steps warrant. Under certain circumstances (e.g., sufficient data exist following Step 3 to adequately characterize risks), some steps of the process may be bypassed.

The steps reported herein include:

- **Screening Level Problem Formulation:** Summarization of the ecological characteristics of the site as well as background and site characterization data collected during field investigation activities, identification of detected analytes, compilation of existing, media-specific ecological benchmark values, selection of COPCs and receptor species for quantitative analysis in the ERA, selection of endpoints to screen for risk, and the development of a CSM.

- **Screening Level Risk Characterization**: Comparison of measured concentrations for COPCs to established benchmarks to determine the potential for adverse effects to receptor species, including a qualitative discussion of the major sources of uncertainty and conservatism inherent in the evaluation.

SECTION 3

Screening Level Problem Formulation

For the screening level problem formulation, a conceptual site model is developed that addresses these five issues:

1. Environmental setting and contaminants known or suspected to exist at the site;
2. Contaminant fate and transport mechanisms that might exist at the site;
3. The mechanisms of ecotoxicity associated with contaminants and likely categories of receptors that could be affected;
4. What complete exposure pathways might exist at the site;
5. Selection of endpoints to screen for ecological risk.

These issues are discussed in the following sections.

3.1 Ecological Setting of the Kress Creek and Sewage Treatment Plant Sites

Information in this section was derived from technical memoranda from CH2M HILL to the USEPA summarizing ecological field activities at the KCK and STP sites (CH2M HILL, 1993; 1994; 1995).

The KCK and STP sites lie within the Great Lake and Till Plains sections of the central Lowland Physiographic Province, about 30 miles west of Lake Michigan. This portion of DuPage County is characterized by gently rolling topography, with greater relief near rivers and creeks.

Major land uses and cover types of the KCK and STP areas are varied and interspersed. They range from high-density residential areas to floodplain forest. Portions of the project area lie within or abut the Blackwell Forest Preserve, which contains a mix of wildlife habitat types including forested wetlands, oak-hickory woodlands, and open fields and meadows.

Terrestrial and aquatic community surveys were conducted for the KCK and STP areas, as part of the initial site investigation work completed in 1993 and 1994. For the purpose of the ecological survey work for KCK, the study area at that time was defined as the area extending from the storm sewer outfall to the creek's confluence with the WBDR and from there downstream along the WBDR to the Warrenville Dam. (The KCK Site was later extended downstream to the McDowell Dam.) The study area for STP was defined as the area extending from the STP to the confluence of the WBDR with KCK. Total stream length within the study area for both sites at the time was approximately 4.75 miles.

From within this general study area, sample locations for the terrestrial and aquatic community investigations were selected. Final sampling areas were determined following a site reconnaissance to assess habitat condition, access, and physical conditions of the sites

(Figure 3-1 and Figure 3-2). Detailed information regarding the methods and results of the ecological characterization work are found the Source Characterization and Hydrological Assessment Technical Memoranda (CH2M HILL, 1993; 1994; 1995).

3.2 Terrestrial Communities of the Kress Creek and Sewage Treatment Plant Areas

3.2.1 Riparian and Other Wetland Communities

Wetlands are found near Kress Creek and the WBDR. The two general categories of wetlands in the area are riverine and palustrine (CH2M HILL, 1994). A riverine wetland includes wetlands and deepwater habitats contained within a channel, except those areas dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. The palustrine system includes nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. The three classes of palustrine wetlands found in the area include emergent, forested, and wetlands with unconsolidated bottoms (CH2M HILL, 1994). The emergent wetland is characterized by erect, rooted, herbaceous hydrophytes. A forested wetland is characterized by woody vegetation that is at least 20 feet tall. Areas classified as unconsolidated bottoms include wetland and deepwater habitats with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent (U.S. Department of the Interior, 1979).

Cattails and reed canary grass are common herbaceous plants found in the emergent wetlands of the KCK and STP areas. Box elder, elm, willow, green ash, cottonwood, silver maple, and red dogwood are woody species typically found in the forested wetlands. Near the creek and river, the wetlands classified as palustrine with unconsolidated bottoms are areas that have been excavated in the past but are now either permanently flooded or intermittently exposed. Vegetation is generally found around the edges of these areas and includes herbaceous species such as reed canary grass and cattails, plus woody plants including elm, box elder, and willow.

Vegetation found along the creek and river is typical of the wetland vegetation described above in low areas, plus wooded uplands, residential/urban areas, and parkland. The WBDR crosses through the western portion of the Blackwell Forest Preserve in an area of upland oak woods and forested wetland.

3.2.2 Upland Woods

Upland plant communities in the project area include oak woodlands, oak savanna, field (includes mowed parkland, yards, and old field), and agricultural land. Oak woodlands are found in the project area, especially in the Blackwell Forest Preserve along the WBDR. Trees commonly found in these oak woodlands include bur oak, white oak, red oak, shagbark hickory, and bitternut hickory. Small, remnant areas of oak savanna are present at the Blackwell Forest Preserve. Savannas are plant communities in which trees are present, but their density is so low that grasses and other herbaceous vegetation dominate the community. Bur and black oak are the predominant tree species in the oak savanna.

3.2.3 Meadows or Old Fields

Fields along the WBDR include some successional old fields; however, mowed grass in residential and parkland areas predominate. Grassy areas generally extend to the banks of the river or creek. Vegetation in the successional old fields includes grasses, goldenrods, brambles, and tree saplings. Agricultural fields are also found in the area, but are generally not adjacent to the creek or river.

3.2.4 Wildlife Species

A variety of wildlife species may potentially use the KCK and STP areas. Actual use will ultimately depend on the type and quality of wildlife habitat present. Habitat quality is a function not only of the type and distribution of the various plant community types described above, but on other factors such as the proximity to human disturbance. Preliminary information on wildlife occurrence was obtained from sources within DuPage County, including the Fermi National Accelerator Laboratory and the Forest Preserve District of DuPage County. Additional sources of information included the Illinois Natural History Survey and previously prepared Environmental Impact Statements (EISs) for Kerr-McGee's REF. This information was supplemented with the results of actual onsite surveys conducted in 1993 (CH2M HILL, 1994).

Table 3-1 lists wildlife species potentially present at the sites. This information is based on wildlife inventory data provided by the Forest Preserve District of DuPage County and the results of field surveys; it was presented in the RI report for the Kerr-McGee Reed-Keppler Park Site (also in West Chicago, Illinois). The District's inventory has been developed through a series of faunal surveys of the various preserves of the county, beginning in 1981.

The Forest Preserve District of DuPage County also categorizes each species by an abundance status, such as abundant, rare, etc. As with general species occurrence, actual abundance within the KCK and STP areas will depend on habitat type and quality. Other sources of information, such as wildlife surveys of the Fermi National Accelerator Laboratory, are considered in the discussions below.

Birds

Seventy-five species of birds may potentially occur within the KCK and STP study areas based on information from the Blackwell Forest Preserve (Table 3-1). Within the nearby preserve, species such as the Mallard (*Anas platyrhynchos*), Canada Goose (*Branta canadensis*), American Robin (*Turdus migratorious*), Common Grackle (*Quiscalus quiscula*), and House Sparrow (*Passer domesticus*) are considered abundant, while many others are considered common. Species such as the Eastern Bluebird (*Sialia salia*) and Blue-Gray Gnatcatcher (*Polioptila caerulea*) were considered rare. Of the 75 known species to use the area, 32 were confirmed to be present within the KCK study area and 25 in the STP study area, based on the results of in-field surveys.

A 1988 survey of bird species occurrence at the Fermi National Accelerator Laboratory reported a significantly greater number of bird species (CH2M HILL, 1994). Two hundred and twenty-four species were identified at Fermi Laboratory during 1987-1988 survey period, including 17 species on the state endangered list. Although the greater number and diversity of avian species at the Fermi Laboratory is certainly due to the greater extent and number of types of available habitat, results of the survey would suggest a diverse population of avian species may occur in DuPage County either as breeding residents or migrants. The Forest Preserve District of DuPage County reports a total of 132 resident and 162 migrant bird species for the entire county.

Amphibians and Reptiles

Six species of amphibians and nine species of reptiles are reported for the Blackwell Forest Preserve. Three species, the bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), and eastern garter snake (*Thamnophis semifaciata*), were observed onsite during the 1993 surveys. Many of the other common species, such as American Toad (*Bufo americanus*) and Common Snapping Turtle (*Cheyldra serpentina*), could be expected to occur within the KCK and STP study areas. The EIS relating to the Kerr-McGee REF (1982) listed four additional amphibian and reptile species as likely to occur on or near the Kerr-McGee facility. These included the Eastern Mud Turtle (*Terrapene carolina carolina*), the Gopher Tortoise (*Gopherus polyphemus*), the Spring Peeper (*Hyla crucifer*), and the Striped Chorus Frog (*Pseudacris trisertiata)*. The extent to which these species may or may not be present in the KCK and STP areas is unknown. The Forest Preserve District of DuPage County reports a total of 16 amphibian and 23 reptiles species for the entire county (Table 3-1).

Mammals

Ten mammal species or their sign were observed within the KCK and STP project area, while an additional 17 species of mammals are reported for the Blackwell Forest Preserve. These range from common species such as the Raccoon (*Procyon lotor*) to the rare Least Weasel (*Mustela rixosa*). Many of the more common mammal species were confirmed to be present in the study area. The EIS relating to the Kerr-McGee REF also reported the Deer Mouse (*Peromyscus maniculatus*), the Norway Rat (*Rattus norvegicus*), the Longtail Weasel (*Mustela frenata*), and the Prairie Vole (*Microtus ochrogaster*) as likely to occur in the area. A total of 45 mammal species for DuPage County are reported by the Forest Preserve District (Table 3-1).

3.3 Aquatic Communities

The physical characteristics of the KCK stream channel differ dramatically throughout the study area. This is the result of the extensive channelization and urbanization within its watershed. Upper portions of the creek were found to contain more silt, while the lower portions contained more gravel and cobble in the substrate. The water in the upper reaches appears to carry a much greater silt load. Water quality parameters, which were measured during the 1993 in-field characterization survey, varied, but were found to be within the range for the support of aquatic life.

The physical characteristics of the WBDR (including both STP River and KCK site portions of the River) were also found to vary, with the upper portion of the river containing more gravel, sand, and detritus than the lower portion, which contained more silt and sand as a result of the Warrenville Dam impoundment at the southern end. The water quality parameters measured throughout the WBDR were within the critical limits for the support of aquatic life.

Habitat assessment criteria, which were also evaluated during field surveys of the site, were used to qualitatively assess habitat quality. In general, the habitat within Kress Creek was found to contain many limiting factors. Based on the assessment, the habitat quality generally improved in a downstream direction, providing the best habitat for the support of aquatic life.

3.3.1 Aquatic Macroinvertebrates

The aquatic macroinvertebrate community structure within KCK was found to vary. The upper portions of the creek were dominated by organisms that are more tolerant of silt-laden substrates. Few intolerant species, such as mayflies and caddisflies, were seen in the upper portions. The lower portions of the creek experience a distinct change in community structure with an increase in the mayfly and caddisfly numbers due to the increase in flow velocity and change in substrate material from silt/sand to a more sand/gravel bottom. The community structure in the WBDR showed similarity in overall composition to the lower portions of the creek, but some differences were noted because of a change in stream order and substrate material.

An extensive collection of invertebrates from the WBDR was conducted by the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Conservation. These collections were made as part of an ecological assessment of the DuPage River Basin (IEPA/WPC/88-010 1988). Two sites, GBK-07 and GBK-05, were sampled on the WBDR just upstream and downstream of the confluence with KCK, respectively. Table 3-2 contains the macroinvertebrate inventory taken during the study. Results from this study also suggest a restrictive environment dominated by organisms that can handle tolerate enrichment, and are common in lotic, erosional environments.

3.3.2 Fish Communities

The fish community of KCK was found to be dominated by non-game species such as carp, sucker, and creek chub. Green sunfish were the only abundant game species present. Some bass and crappie were also collected in the creek, but in few numbers. The fish community structure in the WBDR was also found to be dominated by sucker and green sunfish. Physical anomalies noted in some fish included reddening of caudal fin areas and trematode infestation.

The IEPA (1988) has also conducted fish population assessments in the WBDR as part of their stream classification system. Two of their sampling stations (GBK-07 and GBK-12) were near the WBDR study area. By far, the most prevalent species are carp, minnows, and white suckers (Table 3-3). These results were consistent with the results of project specific fish community surveys conducted at the Kress Creek Site.

Based on Biological Stream Characterization ratings for the streams of Illinois (IEPA/WPC/89-275, 1989), Station GBK-07, upstream of the confluence of KCK on the WBDR, has been designated as Stream Class D, limited aquatic resource. This class has poor biotic resource quality, with the fish community dominated by tolerant forms. The species richness may be notably lower than expected for geographic area, stream size, or available habitat. Station GBK-12, downstream of the KCK confluence, was also designated as Stream Class D. GBK-05, also downstream of the confluence, was designated as Stream Class C, which is moderate aquatic resource. This class has fair biotic resource quality, and fish consist primarily of bullheads, sunfish, and carp. The topic structure is skewed with increased frequency of omnivores and tolerant species.

3.4 Rare, Threatened, and Endangered Species

State or federally listed rare, threatened, or endangered species can be of particular concern in an ecological assessment due to their population status and sensitivity. At the time of the initial community assessment, the only federally listed threatened and endangered wildlife species known to the general project vicinity was the Indiana bat (*Myotis sodalis*). This species, which is currently listed as endangered, is known to occur in the county. Indiana bats inhabit floodplain and riparian woodlands during spring and summer months and over winter in caves. Nursery roosts are generally located under the shagging bark of dead or dying trees, where females bear usually one young. At the time of the original survey, the Forest Preserve District of DuPage County listed Lyman Woods and Waterfall Glenn Preserve as locations of known occurrence of the Indiana bat since 1980. This species was reportedly mist-netted at Lyman Woods on August 27, 1986.

Additionally, two federally threatened plant species are known to exist in DuPage County, the Eastern Prairie Fringed Orchid (*Platanthera leucophacea*), which occupies wet grassland habitat, and the Prairie Bush Clover (*Lespedeza leptostachya*), which occupies dry to mesic prairies with gravelly soils.

Information on state listed threatened and endangered species of the nearby Blackwell Forest Preserve was provided by preserve personnel. Known sightings include the Yellow Headed Blackbird (*Xanthocephalus xanthocephalus*), the Black Tern (*Chlidonias niger*), the Common Moorhen (*Gallinula chloropus*), and the Black-Crowned Night Heron (*Nycticorax nycticora*x) (W. Lamjsa, personal communication 1992). Countywide, the Forest Preserve District, in their inventory of the flora and fauna of the preserves of DuPage County, also lists three additional state listed species, including one endangered (Great Egret/ *Casmerodius albus*), one threatened (Veery/*Catharus fuscescens*), and one watch species (Least Weasel/*Mustela rixosa*).

3.5 Summary of Available Analytical Data

Soil, sediment, and surface water samples were collected at the KCK and STP sites during 1993 through 1995, and 1999 through 2001. Additionally, fish tissues (white sucker and carp) were collected from the creek and the WBDR.

Sample analyses included radionuclides, metals, SVOCs, VOCs, PCBs, and pesticides, although not all media were analyzed for all of these constituents. More detailed information regarding the sampling and analyses performed at the KCK and STP Sites may be found in the RI Report for the Kress Creek and STP Sites (BBL, 2004). All analytical results also are presented in that report.

All positive analyte detections, including those with J qualifiers (i.e., estimated concentrations) were incorporated into this evaluation. Exposure point concentrations were developed using one-half the detection limit for non-detects, where applicable.

It should be noted that, for the purposes of this screening ERA, the data summarized for fish tissue (i.e., metals and radionuclides) were not considered quantitatively except to compare to background constituent concentrations. No ecologically-based benchmark values are available for fish tissue. However, the occurrence of COPCs in fish is indicative of the potential for food transfer and the attendant potential for impacts to higher trophic level organisms. Should a full baseline risk assessment be undertaken, these data could form the basis of dose estimates for piscivorous and omnivorous upper trophic level receptors.

3.5.1 Preliminary Conceptual Site Model

Information on the habitat features at the site and on the fate and transport of the chemicals detected at the site were used to construct CSMs (Figures 3-3 through 3-8). Key components of the CSM include the identification of potential sources of contamination (and identification of COPCs), transport pathways, exposure routes, and receptors. These components are described below.

Sources of Contamination

The waste materials transported from the REF contained a wide range of constituents, including tailings from processed ores, possibly untreated ores, and waste products from other process and manufacturing activities. Numerous sampling and analysis programs were conducted on the original waste materials at the REF. The radiological residuals include thorium, uranium, and their radioactive decay products. Additionally, there may also be natural sources of toxic and bioaccumulative substances in the river system such as weathering and erosion of terrestrial soils, bacterial decomposition of vegetation and animal matter, and long-range transport of substances originating from forest fires or other natural combustion sources.

3.5.2 Identification of Preliminary Constituents of Potential Concern

In order to focus the risk assessment on those constituents that are most likely to cause significant ecological effects, a tiered screen was performed on each medium of concern for the KCK and STP Sites, which considered nutritional status, frequency of detection, comparison to respective background concentration and a comparison with ecological benchmarks. The results of this elimination process are described below and illustrated on Tables 3-4 through 3-8; the risk screens are presented in subsequent sections.

Both chemical and radionuclide contaminants have been detected at all three investigation areas. Radionuclides are defined as contaminants that induce toxicity through the emission of ionizing radiation. Chemical contaminants are those that have toxic effects independent of radiological properties and include metals, SVOCs, VOCs, pesticides and PCBs.

Some chemical contaminants such as uranium possess both chemical and radiological toxicity. However, there are no ecological benchmark values for uranium for the aquatic and terrestrial receptors of concern at the KCK and STP Sites. As a result, the chemical toxicity of uranium was not evaluated in this document. Those chemical toxicity studies that do exist in the open literature are not robust and are not sufficiently representative of site conditions to be applicable for use in this document. It is also expected that, on the population level, the radiological effects of uranium would supercede any potential chemical effects to ecological receptors and, therefore, the radiological benchmarks should be considered adequately protective.

Essential Nutrients

The nutrients calcium, magnesium, potassium and sodium were removed from the constituent lists.

Detection Frequency

A constituent was eliminated if frequency of detection (i.e., the number of positive detections relative to the overall number of analyses) was less than 5 percent.

Background Comparison

Background data for inorganic chemicals and radionuclides were collected from surface soils and sediment from unimpacted areas within KCK and from an adjacent unimpacted area of the WBDR at the STP (performed during the 1993 sediment sampling program conducted by the USEPA). In addition, background concentrations of inorganics in surface water were obtained from these locations (data were unavailable for radionuclide analytes in surface water). Fish tissue was also collected for background comparison. These data sets were combined (i.e., KCK and STP, by medium) and formed the basis for a screen of measured site concentrations of detected analytes to naturally occurring background levels.

An analyte was considered to be not significantly different from background if the maximum of detected values was below the maximum of data from the combined background data set. Tables 3-9 through 3-12 summarize the comparisons of maximum analyte detections to background levels for surface soils, sediment, surface water and fish tissue. This was performed for KCK sediments, STP sediments, STP upland soils, KCK surface water, and STP surface water.

Benchmark Comparisons

A critical step in any risk assessment is the identification of the contaminants that will be included in the quantitative analysis of the potential for adverse effects to receptors. For the purposes of the ERA, the COPC selection process is straightforward and limited in scope.

As described previously in this document, a variety of analytical procedures were performed to characterize the suite of contaminants in surface soils, sediments and surface water, and some constituents were eliminated from further consideration, as described above. From the remaining group of constituents, two types of risk screening procedures were performed to further limit the list of COPCs to those contaminants that are projected to be the most deleterious to ecological receptors. One was performed for radionuclides; the other was performed for the following groups of chemical contaminants; semivolatile organic chemicals (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and inorganics. A discussion of these two methods is provided below.

Radionuclide Screening. Radionuclide concentrations in the media of concern were screened for potential ecological effects using the U.S. Department of Energy’s (DOE’s) RAD-BCG model (DOE, 2002). The rationale of the model is based on several biological principles derived from the literature (IAEA, 1992):

- Aquatic animals are no more sensitive than other organisms; however, because they are poikilothermic animals, temperature can control the time of expression of radiation effects.

- The radiosensitivity of aquatic organisms increases with increasing complexity, that is, as organisms occupy successively higher positions on the phylogenetic scale.
- The radiosensitivity of many aquatic organisms changes with age or, in the case of unhatched eggs, with the stage of development.
- Embryo development in fish and the process of gametogenesis appear to be the most radiosensitive stages of all aquatic organisms tested.
- The radiation-induced mutation rate for aquatic organisms appears to be in between that for fruit flies and mice.
- Appreciable effects in aquatic populations would not be expected at doses lower than 1 rad/d (10 mGy/d); limiting the dose to the maximally exposed individuals to less than 1 rad/d would provide adequate protection of the population.

Additionally, the IAEA (1992) summarized information about the effects of chronic ionizing radiation on terrestrial organisms as follows:

- Reproduction (encompassing the processes from genetic formation through embryonic development) is likely to be the most limiting endpoint in terms of survival of the population.
- Sensitivity to chronic radiation varies markedly among different taxa; certain mammals, birds, reptiles and a few tree species appear to be the most sensitive.
- In the case of invertebrates, indirect responses to radiation-induced changes in vegetation appear to be more critical than direct effects.
- Irradiation at chronic dose rates of 1 rad/d (10 mGy/d) or less does not appear likely to cause observable changes in terrestrial plant populations.
- Irradiation at chronic dose rates of 0.1 rad/d (1 mGy/d) or less does not appear likely to cause observable changes in terrestrial animal populations. The assumed threshold for effects in terrestrial animals is less than that for terrestrial plants, primarily because some species of mammals and reptiles are considered to be more radiosensitive.
- Reproductive effects on long-lived species with low reproductive capacity may require further consideration.

Additional summaries and reviews of radiation effects data on biota confirmed these findings; a discussion of these reviews may be found in DOE (2002).

Therefore, this model provides a graded approach to evaluate compliance with specified limits on radiation dose to populations of aquatic animals, terrestrial plants, and terrestrial animals. Specifically, these dose limits are:

- **Aquatic animals**: The absorbed dose to aquatic animals should not exceed 1 rad/d (10 milliGrays per day [mGy/d] or 0.4 milliGrays per hour [mGy/h]) from exposure to radiation or radioactive material releases into the aquatic environment. This dose limit is specified in DOE Order 5400.5.

- **Terrestrial plants**: The absorbed dose to terrestrial plants should not exceed 1 rad/d (10 mGy/d) from exposure to radiation or radioactive material releases into the terrestrial environment.
- **Terrestrial animals**: The absorbed dose to terrestrial animals should not exceed 0.1 rad/d (1 mGy/d) from exposure to radiation or radioactive material releases into the terrestrial environment.

Avoiding measurable impairment of reproductive capability is deemed to be the critical biological endpoint in establishing the dose limits for aquatic and terrestrial biota. As stated above, appreciable population effects would not be expected at doses lower than 1 rad/d and 0.1 rad/d, respectively, thereby establishing a level of adequate protection.

Internal and external sources of dose (and their contributing exposure pathways) were incorporated into the derivation of the graded approach methodology, and are based on the following general dose equation:

$$LimitingConcentration = \frac{DoseRateLimit}{(InternalDoseRate) + (ExternalDoseRate_{soil/sed}) + (ExternalDoseRate_{water})}$$

The limiting concentration in an environmental medium was calculated by first setting a target total dose (e.g., 1 rad/d) and then back-calculating the medium concentration necessary to produce the applicable dose from radionuclides in the organism (internal dose), plus the external dose components from radionuclides in the environment (external dose). The denominator of the generic equation represents the dose per unit media concentration and may be broken down into the base components of internal and external doses. Internal doses originate from radionuclides inside the organism's body. The internal dose is calculated as the product of the internal radionuclide concentration and an internal dose conversion factor. External doses originate from radionuclides external to the organism and are calculated as the product of the radionuclide concentration in the environmental medium in which the organism resides and an appropriate dose conversion factor.

The DOE defines a biota concentration guide (BCG) as the limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of populations of aquatic and terrestrial biota to be exceeded. The BCGs used in the model are derived from the most sensitive potential receptor for which radionuclide toxicity data exist (for reproductive effects) for a given constituent.

Therefore, these receptors should be considered conservative indicators of risk and protective of less sensitive species. The receptors used are:

- "Riparian animal"
- "Terrestrial animal"
- "Aquatic animal"
- "Terrestrial plant"

The model compares a representative radionuclide concentration with generic BCGs and calculates a fraction, and in turn, these fractions are summed for each radionuclide in each medium. If the sum of all fractions is greater than 1.0, then the site does not pass the screen.

Because this approach is intended to be graded, performing the screen with the maximum detection of each radionuclide is considered the first tier, and therefore the most conservative evaluation. The second tier screen uses the arithmetic mean of constituent concentrations in order to be more realistic of actual site conditions.

For aquatic evaluations, the use of radionuclide concentration data from co-located sediment and surface water samples results in a less conservative, more realistic analysis. In the absence of one of the two media, the model derives the missing BCGs using a conservative sediment distribution coefficient (kd) to calculate the environmental media radionuclide concentration. Results of the RAD-BCG screening are presented in the Risk Characterization section below.

Chemical Contaminant Screening. Chemical COPCs were selected on the basis of a comparison to existing ecologically-based benchmark values where applicable.

As noted above, existing media-specific benchmark values were identified as the preferred basis for comparison to constituent concentrations at the site. These benchmark values were obtained from several sources, each using unique methodologies and protocols in development of the respective values. The assumptions and methods followed in developing these benchmarks are described in the sources cited and the reader is referred to those publications for these details. In general, highly conservative assumptions are used in the development of these media and constituent-specific benchmarks. The intent of such an approach is to provide an estimate of a threshold concentration below which adverse effects are considered unlikely to even the most sensitive receptors, taking into account uncertainties associated with the data. The benchmarks utilized in the risk characterization may vary according to the differences in assumptions and methods followed. As an added measure of conservatism for COPC selection and risk characterization in the ERA, the lowest reported value was used in comparisons.

As noted on these data tables, the literature sources referenced for benchmarks for SVOC and/or metal constituents are as follows:

- Soils
  - Efroymson et al. 1997a; 1997b (Oak Ridge National Laboratory [ORNL])
  - Beyer 1990
- Sediment
  - Jones et al. 1987
  - Long et al. 1995
  - USEPA 1996a
  - Persaud et al. 1993
  - NOAA 1999
- Surface Water
  - USEPA 1996b
  - Suter and Tsao 1996 (ORNL)
  - NOAA 1999

Maximum constituent concentrations were compared to these benchmarks and a hazard quotient (HQ) was developed as follows:

$$HQ_i = C_i / TRV_i$$

Where:

HQ	= Hazard quotient for a given chemical in media i (unitless)
C_i	= Concentration of the chemical in media i (milligrams per kilogram [mg/kg] or micrograms per liter [µg/L])
TRV	= Toxicity reference value for a given chemical in media i (mg/kg or µg/L)

Chemicals with HQs greater than or equal to 1.0 were considered COPCs in the SERA.

Those constituents for which benchmarks do not exist were not analyzed quantitatively; a list of these is provided on Table 3-13; results of chemical contaminant screening are presented below in the Risk Characterization section.

3.5.3 Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors via exposure to affected media. Exposure, and thus, potential for risk, can occur only if complete exposure pathways exist. As shown in Figures 3-3 through 3-8, the project area has potentially complete exposure pathways to ecological receptors.

The COPCs at the Sites originated at the REF many years ago. The primary transport mechanism for the COPCs (radionuclides, SVOCs, pesticides, PCBs) was adsorption to soil, sediment and suspended particulates. In Kress Creek and the WBDR, eventual redeposition downstream transported constituents into site media where they became available to biota. The current sources of contamination at the Sites are the contaminated soils at Upland STP and sediments and floodplain soils in Kress Creek and the WBDR. (See Figures 3-3 through 3-8.)

Exposure of ecological receptors to contaminants at the KCK and STP Sites is expected to occur primarily through ingestion and direct contact with contaminated surface soil, sediment, and surface water and through indirect exposure via ingestion of plant and prey items and subsequent bioaccumulation of contaminants through the food web.

It should be noted that a number of pathways at the site were potentially complete but not evaluated quantitatively in this SERA. For example, it is assumed that, while dermal contact with soil-bound contaminants could occur, the ingestion exposure route (both incidental ingestion of impacted media and food web exposures) likely accounts for the most significant dose for COPCs. Additionally, exposures associated with inhalation of and direct dermal contact with some COPCs may occur for some receptors, but it is assumed that such exposures are insignificant in relation to those associated with ingestion.

The following subsections provide brief discussions on the physicochemical characteristics as they relate to environmental disposition and the potential ecotoxicity of the COPCs at the KCK and STP sites.

Fate and Transport of the Constituents of Potential Concern

It is assumed that the surface water runoff from the REF was the primary mechanism for contamination reaching KCK. The outfall pool and the creek segment immediately below are the location of the highest concentrations of sediment contamination. Secondary contaminant mechanisms include surface water runoff from contaminated properties within the KCK site watershed.

The primary migration mechanisms that may lead to the spread of contamination from the down stream area near the outfall are:

- Sediment transport and deposition within the stream to unaffected reaches
- Leaching of contaminants of concern from floodplain soils and sediments to surface water or groundwater
- Erosion of floodplain soils to the stream

The distribution coefficient for radium is approximately 250 mL/g and for thorium is 60,000 mL/g (Table 3-14). On the basis of these coefficients, radium and thorium particles are retained in soils and sediments. Because sediments and soils in the affected area tend to contain high percentages of fine materials (organic matter and clay), it is unlikely that radium and thorium will leach from the soil or sediments. Uranium has a lower distribution coefficient (45 mL/g), and thus may have a higher tendency to leach from soils and sediments.

Most metals have higher distribution coefficients (Table 3-15) and can be expected to react in the same way as radium and thorium. Exceptions are arsenic (1 to 18 mg/L), iron (1.4 to 1,000 mg/L), and selenium (1.2 to 8.6 mg/L), which have relatively low distribution coefficients and can be expected to leach.

The primary organic chemicals of concern identified at the site are PAHs, which generally have high partition coefficients (K_{oc}). They are not expected to leach from the soils or sediments.

Ecological Toxicity

Radionuclides. In general, the more primitive organisms are the most radioresistant taxonomic groups and the more advanced complex organisms, such as mammals, are the most radiosensitive. The early effects of exposure to ionizing radiation result primarily from cell death; cells that frequently undergo mitosis are the most radiosensitive, and cells that do not divide are the least. Thus, embryos and fetuses are particularly susceptible to ionizing radiation and very young animals are consistently more radiosensitive than adults (see review in Eisler, 1994).

In addition to the evolutionary position and cell mitotic index, many extrinsic and intrinsic factors modify the response of a living organism for a given dose of radiation. Abiotic variables include the type and energy of radiation, exposure rate, length of exposure, total exposure and absorbed dose, dose rate, spatial distribution of dose, season, temperature, day length, and environmental chemicals; biotic variables include nutritional status, sensitizing or protective substances, competition, parasitism, and predation (Whicker and Schultz, 1982; Hobbs and McClellan, 1986; USCEAR, 1988; Kiefer, 1990).

Radiosensitivity of cells is related directly to their reproductive capacity and indirectly to their degree of differentiation (Hobbs and McClellan, 1986). Early adverse effects of exposure to ionizing radiation are due mainly to the killing of cells. Cell death may result from the loss of reproductive integrity (i.e., inability to undergo mitosis). Reproductive death is important in rapidly dividing tissues such as bone marrow, skin, gut lining, and germinal epithelium. When the whole animal is exposed to a large dose of ionizing radiation, some tissues are more prone to damage than others. Death rates of mammalian reproductive cells from ionizing radiation is modified by variations in the linear energy transfer of the radiation, the stage in the cell cycle, cell culture conditions (artifact), and sensitizing and protecting compounds (Barendsen, 1990). The chemical form of the main stage of the acute radiation syndrome depends on the size and distribution of the absorbed dose. It is determined mainly by damage to blood platelets and other blood-forming organs at 4-5 Gy, to epithelial cells lining the small intestine at 5-30 Gy, and to brain damage at more than 30 Gy; death usually occurs within 48 hours at more than 30 Gy (McLean, 1973).

Radioactive materials that gain entry to the body typically, through ingestion or inhalation, exert effects that are governed by their physical and chemical characteristics, which in turn influence their distributions and retention inside the body. In general, the radiation dose from internal emitters is a function of the effective half-time, energy released in the tissue, initial amount of introduced activity and mass of the organ (Hobbs and McClellan, 1986). Retention of radionuclides by living organisms is quite variable and modified by numerous biologic and abiotic variables (Eisler, 1994).

Chemical Contaminants. Several inorganics were positively detected in soil and sediment at the KCK and STP Sites. Of these, mercury is the only inorganic compound that both bioaccumulates and biomagnifies through the food chain. Mercury exposure could be important for the higher order predators that forage at the sites. The biological transformation of a variety of forms of mercury to methylmercury (the most toxic form) can take place in both terrestrial and aquatic environments (Olson and Cooper, 1977; and Rogers, 1976 *cited in* Heinz, 1996). Other inorganic compounds detected at the sites that will bioaccumulate include lead, copper, and zinc. There are a variety of toxic mechanisms associated with metals.

PAHs are virtually ubiquitous in nature, primarily as a result of natural processes such as forest fires, microbial synthesis, and volcanic activity. They have been detected in animal and plant tissues, sediments, soils, air, surface water, drinking water, and groundwater. Anthropogenic sources of PAHs in the environment include high temperature combustion of organic materials typical of processes used in the steel industry, heating and power generation, and petroleum refining. PAHs in surface soils may be assimilated by plants, degraded by soil microorganisms, or accumulated to relatively high levels in the soil (Eisler, 1987).

In some plants growing in highly contaminated areas, assimilation may exceed metabolism and degradation, resulting in accumulation in plant tissues. Laboratory experiments have demonstrated that plants can bioaccumulate PAHs to levels above those found in the environment, although this has not been conclusively demonstrated in field-grown plants. Uptake can be by both leaves (atmospheric deposition) and roots (soils and sediments) with subsequent translocation to other plant parts. Uptake is variable by plant species and soil conditions. Little data are available on bioaccumulation by vegetation and trophic transfer to higher level consumers in terrestrial and aquatic food chains (Eisler, 1987).

PAHs are moderately persistent in the environment and therefore may potentially cause significant effects to vegetation, fish, and wildlife. The carcinogenicity of individual PAHs differs. Some lower weight compounds such as naphthalene, fluorenes, phenanthrenes, and anthracenes exhibit acute toxicity and other adverse effects to some organisms, but are non-carcinogenic. In contrast, the higher molecular weight compounds are less acutely toxic, but many are carcinogenic, mutagenic, or teratogenic to a wide variety of organisms.

The pesticides detected at the sites are organochlorine compounds. The most serious environmental effects associated with exposure to organochlorine pesticides have occurred in birds. These effects include mortality, eggshell thinning, reduced reproductive success, population decline, and, in some cases, extirpation (Blus et al., 1996). Organochlorine pesticides are accumulated in lipids and biomagnify through the food chain.

The group known as PCBs contain congeners of differing persistence and toxicity in the environment. In general, PCB isomers with high lipophilicity and high numbers of substituted chlorines in adjacent positions constitute the greatest concern to wildlife due to their potential for bioaccumulation (Eisler, 1986). Among sensitive avian species, PCBs disrupt normal patterns of growth, reproduction, metabolism, and behavior. In general, PCB accumulation is rapid and depuration proceeds at a much slower rate (NAS, 1979).

Potential receptors at the sites include organisms that have significant direct contact with the soil. These could include plants, soil invertebrates, and animals that forage in soil or on organisms that have a high level of contact with the soil.

3.5.4 Ecological Receptors of Concern

A critical element of the problem formulation process is the identification of representative receptors that occur within the project area. As per USEPA guidance (USEPA, 1997), these receptors should be conservative choices that are representative of the most highly exposed receptors to site media, groups essential to normal functioning of habitat, and federal or state threatened or endangered species.

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, specific receptor species (e.g., great blue heron) or species groups (e.g., fish) are often selected as surrogates to evaluate potential risks to larger components of the ecological community (feeding guilds such as piscivorous birds) and are used to represent the assessment endpoints (e.g., survival and reproduction of piscivorous birds).

In the project area, the ecological receptors potentially at risk are those plants and animals that utilize terrestrial and aquatic habitats. Relevant groups of organisms include microbiota, aquatic and terrestrial plants, benthic/epibenthic macroinvertebrates, zooplankton, fish, reptiles, birds and mammals. These receptors were selected based on the habitat provided by the project area, the nature of COPCs (primarily soil- and sediment-associated contaminants and bioaccumulative compounds), and their high likelihood for exposure to COPCs. As such, they are considered the most at-risk receptors and are protective of receptor groups that would have less exposure to the affected environment. Relevant ecological receptors are discussed below.

Upper trophic level receptor species quantitatively evaluated in the ERA were limited to birds and mammals, the taxonomic groups with the most available information regarding exposure and toxicological effects. Lower trophic level receptor species were evaluated in the ERA based upon those taxonomic groupings for which screening values have been developed; these groupings and screening values are used in most ERAs. As such, specific species of aquatic biota (e.g., macroinvertebrates) were not chosen as receptor species because of the limited information available for specific species and because aquatic biota are considered on a community level via a comparison to surface water and sediment screening values. Similarly, aquatic plants are considered protected by the federal Ambient Water Quality Criteria.

Additionally, other receptors that may be present onsite are threatened and/or endangered species such as the Indiana bat. Risks to this species cannot be estimated due to the paucity of toxicity values from the literature for this or related species. However, those receptors for which risk can be quantified would be expected to have greater potential exposure and, therefore, would be protective of other receptor groups with less exposure.

The following groups of receptors were evaluated using the hazard quotient screening technique described above.

Microbial Community

Microbial communities consist of bacteria, protozoans, and fungi and play several essential roles in ecosystems. They facilitate the degrading and transforming of detrital organic matter for ingestion by higher level consumers and serve as an important food source for a variety of larval and adult organisms. Additionally, microbes also play a role in the cycling and transformation of nutrients and sediments in the water column. The sediment microbial community would be at risk due to the direct exposure such communities might have to sediment-associated contaminants. Exposure of the microbial community to COPCs in the project area may significantly change or reduce community diversity. In turn, geochemical functions may be altered, reducing the productivity of these communities upon which many other receptors depend. Although specific information on the composition of the microbial community in the KCK/STP area is not available, this community is an essential component of the ecosystem.

Plants

As primary producers, plants are an important food source for herbivorous organisms and also provide essential habitat for a variety of aquatic and terrestrial species at all life stages. Plants are an essential component of ecosystems and exposure to contaminants may result in a loss of productivity within the ecosystem and limit the ability of the site to support ecological resources.

Invertebrates

Invertebrates (i.e., primary consumers) serve an important function in the aquatic and terrestrial food webs by consuming plants, detritus, etc., and are a food source for fish, birds and mammals. They represent an important link between organic matter and higher trophic level consumers. They are in intimate contact with sediments and soils and may be highly exposed to adsorbed contaminants. Reducing or impairing the function of invertebrate organisms may disrupt the flow of energy within the ecosystem. Therefore, impacts to this portion of the food web may have profound consequences to wildlife receptors, potentially resulting in decreases in fish, reptile, avian, and mammalian populations in and around the project area.

The following upper trophic level receptor species have been chosen for exposure modeling with media at the Sites based on the criteria listed above; it should be noted that these receptors were evaluated for bioaccumulation and food web transfer of chemical constituents only. Radionuclide bioaccumulation was accounted for with similar receptors in the RAD-BCG screening models.

Mammals

Deer Mouse (*Peromyscus maniculatus*)—Terrestrial Mammalian Omnivore. Deer mice feed on seeds, berries, acorns, fruits, insects, and other small invertebrates, and serve as food for a variety of carnivores. They are the direct link in the terrestrial food chain between plants and higher trophic level organisms.

Least Shrew (*Cryptotis parva*)—Terrestrial Mammalian Insectivore. Shrews feed mainly on insects, earthworms, and other invertebrates, and would be expected to ingest significant amounts of soils incidentally through foraging and prey consumption.

Mink (*Mustela vison*)—Semi-Aquatic Mammalian Piscivore. Mink are top level carnivores that feed on fish, small mammals, birds, eggs, frogs, and macroinvertebrates. They are also known to be sensitive to environmental contaminants.

Raccoon (*Procyon lotr*)—Semi-Aquatic Mammalian Ominivore. Raccoons are most common in and around wetland areas, where they search for small aquatic animals like fish, crayfish, and freshwater mussels in the shallow water. Besides aquatic life and other animal matter, raccoons also eat a variety of fruits, berries, and seeds.

Birds

American Robin (*Turdus migratorius*)—Terrestrial Avian Omnivore. Robins live in a variety of habitats, including woodlands, swamps, suburbs, and parks. Robins forage on the ground in open areas, along edge habitats, or along the edges of streams. They forage along the ground for ground-dwelling invertebrates and search for fruit and foliage-dwelling insects in low tree branches (Malmborg and Willson, 1988).

Mallard (*Anas platyrhynchos*)—Wetland/Aquatic Avian Omnivore. Mallards consume a wide variety of foods including vegetation, insects, worms, gastropods, and arthropods. Due to their feeding habits, mallards also tend to incidentally ingest significant amounts of sediment during feeding.

Great Blue Heron (*Ardea herodias*)—Wetland/Aquatic Avian Piscivore. Great blue herons represent carnivorous wading birds that feed on a variety of aquatic organisms, including fish, invertebrates, amphibians, and reptiles. Herons do not ingest significant amounts of sediment during feeding activities.

3.5.5 Screening Assessment Endpoints

The conclusion of the problem formulation stage includes the selection of assessment and measurement endpoints, based on the preliminary conceptual model. Endpoints in the SERA define ecological attributes that are to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or could occur. Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the site (USEPA, 1997). Assessment endpoints contain an entity (e.g., fish-eating birds) and an attribute of that entity (e.g., survival rate).

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, receptor species (e.g., great blue heron) or species groups (e.g., fish) are often selected as surrogates to evaluate potential risks to larger components of the ecological community (feeding guilds; e.g., piscivorous birds) represented in the assessment endpoints (e.g., survival and reproduction of piscivorous birds). Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site
- Have a particular ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present at the site for which complete exposure pathways are likely to exist
- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations at the site
- Have sufficient ecotoxicological information available on which to base an evaluation

Based on the habitat and types of contaminants present, seven assessment endpoints were chosen to evaluate the risk to ecological receptor populations from toxic components in KCK and STP site media. Each assessment endpoint and corresponding representative species or community is described below.

Survival and Reproduction of Terrestrial Plant Communities

Plants provide food, cover, and nesting material for many animals. The soils at the sites will support fewer birds and mammals if COPCs are limiting the survival and reproduction of plants.

Survival and Reproduction of Soil Invertebrate Communities

Soil invertebrates promote soil fertility by breaking down organic matter and releasing nutrients. They also improve aeration, drainage, and aggregation of soil, and serve as a forage base for many terrestrial species. The soils at the sites will support fewer insectivorous birds and mammals if chemical concentrations are limiting the survival and reproduction of soil invertebrates.

The endpoints that build on the above and were evaluated in this risk assessment are:

- Survival and reproduction of terrestrial mammalian omnivores (deer mouse)
- Survival and reproduction of terrestrial mammalian insectivores (least shrew)
- Survival and reproduction of terrestrial avian omnivores (American robin)

Assessment endpoints with aquatic bases that were evaluated herein are:

- Survival and reproduction of semi-aquatic mammalian piscivores (mink)
- Survival and reproduction of semi-aquatic mammalian omnivores (raccoon)
- Survival and reproduction of semi-aquatic avian omnivores (mallard)
- Survival and reproduction of semi-aquatic avian piscivores (great blue heron)

Endpoints specific to reptiles and amphibians were not selected, although potential exposure pathways may exist for these receptors. There is a lack of herpetofauna-specific toxicological data for most environmental contaminants. Reptiles and amphibians are indirectly assessed via the bird and mammals evaluations since they are not likely to be more sensitive than the receptors evaluated (Hall and Henry, 1992). Birds and mammals have been selected that have similar diets to the herpetofauna that could potentially inhabit the KCK and STP sites.

The corresponding measurement endpoints associated with each assessment endpoint were defined as follows:

Assessment Endpoints		Measurement Endpoints
Survival and reproduction of soil invertebrate communities.	⇨	Comparison of HQs for soil invertebrates (earthworms) to a target HQ of 1. Medium-specific HQs are calculated for individual contaminants by dividing the maximum soil concentration by a soil benchmark that is intended to be protective of soil invertebrates.
Survival and reproduction of terrestrial plant communities.	⇨	Comparison of HQs for terrestrial plants to a target HQ of 1. Medium-specific HQs are calculated for individual contaminants by dividing the maximum soil concentration by a soil benchmark that is intended to be protective of terrestrial plants.
Survival and reproduction of avian terrestrial omnivores.	⇨	Comparison of HQs for American robin to a target HQ of 1. Receptor-specific HQs are calculated for individual contaminants by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects. Exposure estimates will include contributions from the consumption of plants, invertebrates, and soil.
Survival and reproduction of mammalian terrestrial insectivores.	⇨	Comparison of HQs for least shrew to a target HQ of 1. Exposure estimates will include contributions from the consumption of invertebrates, and soil.
Survival and reproduction of mammalian semi-aquatic omnivores.	⇨	Comparison of HQs for raccoon to a target HQ of 1. Exposure estimates will include contributions from the consumption of plants, invertebrates, fish and sediment.
Survival and reproduction of mammalian semi-aquatic piscivores.	⇨	Comparison of HQs for mink to a target HQ of 1. Exposure estimates will include contributions from the consumption fish and sediment
Survival and reproduction of mammalian terrestrial insectivores.	⇨	Comparison of HQs for least shrew to a target HQ of 1. Exposure estimates will include contributions from the consumption of invertebrates and soil.
Survival and reproduction of avian semi-aquatic omnivores.		Comparison of HQs for mallards to a target HQ of 1. Exposure estimates will include contributions from the consumption of plants, invertebrates, and sediment.
Survival and reproduction of avian semi-aquatic piscivores.	⇨	Comparison of HQs for great blue heron to a target HQ of 1. Exposure estimates will include contributions from the consumption of fish.

SECTION 4

Screening Level Exposure Estimate and Risk Characterization

Upper trophic level receptor exposures to chemical contaminants at the Kress Creek and STP sites were determined by estimating the concentration of each chemical in each relevant dietary component.

4.1 Exposure Point Concentrations

The bioaccumulation of site-related constituents by plants and soil invertebrates (and hence, upper trophic level receptors) was estimated using models and maximum measured media concentrations. The methodology and models used to derive these estimates are described below. It is important to note that only those constituents listed on Table 4-2 of "Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment Status and Needs" (USEPA, 2000) were included in the evaluation of bioaccumulation.

4.1.1 Plants

Tissue concentrations in the aboveground vegetative portion of plants were estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific soil-to-plant bioconcentration factors (BCFs) obtained from the literature. The BCF values used were based on root uptake from soil and on the ratio between dry-weight soil and dry-weight plant tissue. Literature values based on the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for terrestrial plants (15 percent [0.15]; Sample et al. 1997).

For inorganic chemicals without literature based BCFs, a soil-to-plant BCF of 1.0 was assumed. For organic chemicals without literature based BCFs, soil-to-plant BCFs were estimated using the algorithm provided in Travis and Arms (1988):

$$log\ B_v = 1.588 - (0.578)\ (log\ K_{ow})$$

where: B_v = Soil-to-plant BCF (unitless; dry weight basis)
K_{ow} = Octanol-water partitioning coefficient (unitless)

The log K_{ow} values used in the calculations were obtained mostly from USEPA (1995; 1996c) and are listed in Table 4-1. The soil-to-plant BCFs used in the SERA are shown in Table 4-2.

4.1.2 Soil Invertebrates

Tissue concentrations in soil invertebrates (earthworms) were estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific BCFs or bioaccumulation factors (BAFs) obtained from the literature. BCFs are calculated by dividing the concentration of a chemical in the tissues of an organism by the concentration of that same chemical in the surrounding environmental medium (in this case, soil) without accounting for uptake via the diet. BAFs consider both direct exposure to soil and exposure via the diet. Since earthworms consume soil, BAFs are more appropriate values and are used in the food web models when available. BAFs based on depurated analyses (soil was purged from the gut of the earthworm prior to analysis) are given preference over undepurated analyses when selecting BAF values since direct ingestion of soil is accounted for separately in the food web model.

The BCF/BAF values used were based on the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based on the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for earthworms (16 percent [0.16]; USEPA 1993). For inorganic chemicals without available measured BAFs or BCFs, an earthworm BAF of 1.0 was assumed. The soil-to-earthworm BCFs/BAFs used in the SERA are shown in Table 4-2.

4.1.3 Small Mammals

Whole-body tissue concentrations in small mammals (shrews, voles, and/or mice) were estimated using one of two methodologies. For chemicals with literature-based soil-to-small mammal BCFs, the small mammal tissue concentration was obtained by multiplying the maximum measured surface soil concentration for each chemical by a chemical-specific soil-to-small mammal BCF obtained from the literature. The BCF values used were based on the ratio between dry-weight soil and whole-body dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for small mammals (32 percent [0.32]; USEPA 1993). BCFs for shrews were those reported in Sample et al. (1998) for insectivores (or for general small mammals if insectivore values were unavailable), for voles were those reported for herbivores, and for mice were those reported for omnivores.

For chemicals without soil-to-small mammal BCF values, an alternate approach was used to estimate whole-body tissue concentrations. Because most chemical exposure for these small mammal species is via the diet, it was assumed that the concentration of each chemical in the small mammal's tissues was equal to the chemical concentration in its diet, that is, a diet to whole-body BAF (wet-weight basis) of 1.0 was assumed. The use of a diet to whole-body BAF of 1.0 is likely to result in a conservative estimate of chemical concentrations for chemicals that are not known to biomagnify in terrestrial food chains (e.g., aluminum). For chemicals that are know to biomagnify (e.g., PCBs), a diet to whole-body BAF value of 1.0 will likely result in a realistic estimate of tissue concentrations based on reported literature values. For example, a maximum BAF (wet weight) value of 1.0 was reported by Simmons and McKee (1992) for PCBs based on laboratory studies with white-footed mice. Menzie et al. (1992) reported BAF values (wet-weight) for dichlorodiphenyl trichloroethane (DDT) of 0.3 for voles and 0.2 for short-tailed shrews. Reported BAF (wet-weight) values for dioxin were only slightly above 1.0 (1.4) for the deer mouse (USEPA, 1990). Resulting tissue concentrations (wet-weight) were then converted to dry weight using an estimated solids content of 32 percent (see above). The soil-to-small mammal BAFs used in the SERA are shown in Table 4-2.

4.2 Dietary Intakes

Dietary intakes for each receptor species were calculated using the following formula (modified from USEPA 1993):

$$DI_x = \frac{[[\sum_i (FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)] + [(WIR)(WC_x)]]}{BW}$$

where:	DI_x	=	Dietary intake for chemical × (mg chemical/kg body weight/day)
	FIR	=	Food ingestion rate (kg/day, dry-weight)
	FC_{xi}	=	Concentration of chemical × in food item i (mg/kg, dry weight)
	PDF_i	=	Proportion of diet composed of food item i (dry weight basis)
	SC_x	=	Concentration of chemical × in soil/sediment (mg/kg, dry weight)
	PDS	=	Proportion of diet composed of soil/sediment (dry weight basis)
	WIR	=	Water ingestion rate (L/day) (not applicable for this ERA)
	WC_x	=	Concentration of chemical × in water (mg/L) (not applicable for this ERA)
	BW	=	Body weight (kg, wet weight)

Exposure parameters for upper trophic level receptors are presented in Table 4-3.

4.2.1 Ingestion Screening Values

Ingestion screening values for dietary exposures were derived for each avian/mammalian receptor species and bioaccumulating chemical. Toxicological information from the literature for wildlife species most closely related to the receptor species was used, where available, but was supplemented by laboratory studies of non-wildlife species (e.g., laboratory mice) where necessary. The ingestion screening values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day).

Growth and reproduction were emphasized as assessment endpoints since they are the most relevant, ecologically, to maintaining viable populations and because they are generally the most studied chronic toxicological endpoints for ecological receptors. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species. No Observed Adverse Effect Levels (NOAELs) based on growth and reproduction were used, where available, as the screening values. When chronic NOAEL values were unavailable, estimates were derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or acute values as follows:

- When values for chronic toxicity were not available, the median lethal dose (LD_{50}) was used. An uncertainty factor of 100 was used to convert the acute LD_{50} to a chronic NOAEL (i.e., the LD_{50} was multiplied by 0.01 to obtain the chronic NOAEL).

- An uncertainty factor of 10 was used to convert a reported LOAEL to a NOAEL.

Ingestion screening values for mammals and birds are summarized in Tables 4-4 and 4-5, respectively.

Other assumptions used in the models to determine the potential for food web transfer are as follows:

- **Area use**: The portion of a receptors home range that is impacted, assumed to be 100 percent
- **Bioavailability**: The percentage of the concentration of a COPC in an exposure medium that is taken up and metabolized by a receptor, assumed to be 100 percent.
- **Body weight**: The mean body weight of the population of receptors of a given species, assumed to be the minimum reported values by USEPA (1993).
- **Ingestion rates**: The average mass of food or environmental media ingested on a daily basis by the ROC, assumed to be the maximum value reported by USEPA (1993).
- **Bioaccumulation**: The degree to which a COPC concentrates in the tissues of biota at progressively higher trophic levels in the food web. The maximum value reported in the literature reviewed was used. In the absence of a chemical- and/or trophic level-specific value, a default value of 1.0 is assumed.
- **Dietary composition**: The percentage of diet comprised of various prey or forage material. If values are reported for various food items by USEPA (1993), these were incorporated into the calculations (Table 4-3). In the absence of species-specific information, it is assumed that the receptor's diet is comprised entirely of the most contaminated food items.

The results of the food web modeling are presented in the following section.

4.3 Screening Level Risk Characterization

The screening-level risk calculation is the final step in a SERA. In this step, the maximum exposure doses to upper trophic level receptor species are compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of COPCs for each media-pathway-receptor combination evaluated for a conclusion of acceptable or unacceptable risk.

To reiterate, KCK, STP river and STP upland data were screened using the RAD-BCG model to determine risks to aquatic and terrestrial receptors from exposure to radionuclides; the results of those screens are presented here. Chemical COPCs were selected using the HQ method, which entails dividing the exposure dose by the corresponding benchmark. The TRVs used here are media-specific values developed using conservative assumptions regarding toxicity and exposure and are intended to be levels protective of adverse impacts to even highly sensitive species. The lowest value derived from the literature was adopted for the purposes of comparison.

HQs exceeding one indicate the potential for risk since the chemical concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure estimates are derived using intentionally conservative assumptions such that HQs greater than 1.0 do not necessarily indicate that risks are present or impacts are occurring. Rather, such HQs identify chemical-pathway-receptor combinations requiring further evaluation. Following the same reasoning, HQs that are less than or equal to 1.0 indicate that risks are very unlikely, allowing a conclusion of no unacceptable risk to be reached with a high degree of confidence.

The results of the risk screening for each area of concern and each affected medium within the KCK and STP sites are presented in Tables 4-6 to 4-19 and are described further below.

4.3.1 Kress Creek

Radionuclides

A comparison of the maximum radionuclide concentrations detected in KCK site media with DOE's BCGs resulted in the following (see Table 4-6):

- Total sum of fractions in water and sediment was 2.96E+03, and therefore the site screen failed.
- Radium-228 (Ra-228) had a partial fraction of 7.46 in sediment (and a calculated partial fraction of 2.8E+03 in surface water) and appeared to be the risk driver.
- No radionuclide analyses were performed on collected surface water samples, and therefore the resultant screen was based on modeled water concentrations.

A comparison of the mean radionuclide concentrations detected in KCK site media with BCGs resulted in the following (Table 4-7):

- The site screen failed; however, this was based wholly on the calculated partial fractions of Ra-228 (1.2E+02) and radium-226 (Ra-226) (1.4E+01) in water; the total sum of fractions in sediment was below 1.0.
- The default distribution coefficient (k_d) values used in the model for both Ra-226 and Ra-228 are low (70 mL/g; USDOE 2002), indicating a theoretical propensity to migrate into the aqueous fraction; this is the reason for the high calculated partial fractions for these constituents. According to Langmuir (1997) and Oztunali and Roles (1984), radium (Ra) has a K_d value of 250 mL/g for soils similar to those in West Chicago. Therefore, under natural conditions, Ra-226 and Ra-228 remain bound to particulate fractions and measured surface water concentrations would be expected to be lower than those calculated by the model (see further discussion regarding fate and transport characteristics of these constituents above).

Chemical Contaminants

Table 4-8 and Table 4-9 summarize the comparison of maximum and mean analyte concentrations to available benchmark values for KCK sediment and surface water respectively. Constituents were considered risk drivers if the resultant HQ was greater than 10; results of this screen are presented below.

Sediment

Ten inorganic constituents, 13 semivolatile organics, p,p'-dichlorodiphenyl dichloroethane (p,p'-DDD), and Aroclor 1260 were detected in KCK sediments at concentrations exceeding respective ecological benchmarks (i.e., had HQs greater than 1.0). Of these, five metals (arsenic, copper, lead, mercury, and zinc), six polycyclic aromatic hydrocarbons (PAHs) (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, fluorene, and phenanthrene) and DDD and Aroclor 1260 had HQs greater than 10; HQs ranged from 13 to 179 for inorganics, 11 to 39 for SVOCs, 140 for DDD and 870 for Aroclor 1260.

Surface Water

Barium, cobalt, copper, lead and nickel exceeded ecological benchmarks for surface water (i.e, had HQ's greater than 1.0). Barium and copper had HQs greater than 10 (27 and 63, respectively).

Food Web Modeling Results

It appears likely that metals, Aroclor 1260, and some PAHs have the potential to bioaccumulate to significant levels in semi-aquatic receptors that are dependent upon KCK (see Table 4-10). Of these, modeled body burdens of aluminum, lead, mercury, zinc, chrysene, and pyrene in mink, great blue heron, and mallard were the highest relative to ecological benchmarks.

4.3.2 Sewage Treatment Plant River

Radionuclides

The following are the results of the RAD-BCG screen conducted with the maximum constituent concentrations in STP river sediment and surface water (Table 4-11):

- Total sum of fractions in water and sediment was 1.95, and therefore the site screen failed.
- Ra-228 had a partial fraction of 1.25 in sediment and 0.37 in water and was the risk driver.

However, when the mean concentrations were used, the total sum of fractions was below 1.0, and therefore, the site screen passed (Table 4-12).

Chemical Contaminants

STP River Sediment. Nine inorganics exceeded benchmarks in STP sediments (i.e., had HQ's greater than 1.0); only mercury had a maximum hazard quotient of greater than 10 (25). Additionally, four PAHs also had HQs greater than 1, but none were greater than 10 (see Table 4-13).

STP River Surface Water. Six inorganics exceeded benchmarks in STP surface water (i.e., had HQ's greater than 1.0); however, only barium had an HQ greater than 10 (24) (see Table 4-14).

Food Web Modeling Results

The food web model determined that concentrations of accumulated burdens of aluminum, mercury, chrysene, and pyrene in receptors exposed to STP river sediments and surface water exceeded ecotoxicological benchmarks (see Table 4-15). In particular, great blue heron and mallard (i.e., avian receptors that feed primarily on fish and aquatic invertebrates [as well as plants, in the case of the mallard]), had the highest modeled burdens of COPCs relative to benchmarks.

4.3.3 Sewage Treatment Plant Upland Soils

Radionuclides

The following are the results for the RAD–BCG screen conducted with the maximum constituent concentrations in STP Upland Soils (Table 4-16):

- Total sum of fractions in soil was 1.1E+01, and therefore, the site screen failed.
- Ra-228 had a partial fraction of 10 in soil and was the risk driver).

However, when the mean concentrations were used the total sum of fractions was below 1.0, and therefore the site screen passed (Table 4-17).

Chemical Contaminants

Fourteen inorganics exceeded benchmarks in STP surface soils (i.e., had HQs greater than 1.0) as well as 11 PAHs and one volatile organic (toluene). Of these, chromium, lead, manganese, iron, mercury, vanadium, and zinc had HQs greater than 10; HQs ranged from 20.85 (vanadium) to 5,400 (mercury) (see Table 4-18).

Food Web Modeling Results

For terrestrial receptors, metals were the primary accumulated COPCs, in particular lead, mercury, and zinc; cadmium and chromium were also important (Table 4-19). The least shrew and American robin had highest body burdens of these constituents relative to benchmarks, due to high accumulations in invertebrate (insects and earthworms) prey.

SECTION 5

Uncertainty Assessment

Each step in the screening ERA process involves the use of assumptions and protocol that impart uncertainty to the final results. As noted above, whenever possible, assumptions that tend to increase conservatism are adopted to ensure that the likelihood for underestimating the potential for effects is minimized. In some cases, however, the absence of technical information concerning the toxicology of a given constituent or other factors precludes the consideration of a chemical or exposure route in the quantitative assessment. The exclusion of potential COPCs and potentially complete routes of exposure for receptors of concern will tend to be a source of downward bias to estimates of potential for effects. That is, such factors may offset some of the conservatism imparted to the process.

Some of the primary sources of uncertainty and their probable affect on the overall conservatism inherent in the analysis for this SERA are presented below.

5.1 Limiting the Analysis to Constituents of Potential Concern that Exceed Background and Established Benchmarks

More chemicals were detected in media at the sites than were quantitatively evaluated in the SERA. Assuming that the locations where background samples were collected represent unimpacted areas, this is a valid and accepted approach for screening chemicals as part of the risk assessment process. In some cases, background levels exceeded benchmark values, indicating that site concentrations would not increase risk to receptors beyond that experienced in the general environment in the region.

5.2 Use of Established Benchmark Values for Comparison

In general, these values have been developed using highly conservative assumptions regarding chemical fate and transport characteristics, physicochemical properties, ecotoxicological endpoints, and exposure conditions. Consistent with the general principles described by USEPA (1997b) for screening level ERAs, these values tend to incorporate significant margins of error.

5.3 Inability to Quantitatively Evaluate All Detected Analytes

Some chemical constituents could also not be quantitatively evaluated because of the paucity of available toxicological data. Therefore, the potential exists for disregarding constituents that could have an effect on the environment.

5.4 Limiting Evaluation of Potentially Complete Exposure Routes to Ingestion

Other routes of contact with COPCs may be complete for some receptors. In general, it is believed that ingestion of impacted media, forage, and prey items constitute the most significant route for most vertebrate receptors. Moreover, little if any technical information to support the quantitative evaluation of non-ingestion pathways in ecological receptors exists for most chemicals. As such, the uncertainties potentially associated with assumptions that would be necessary to do so would make the results highly questionable.

5.5 Use of Default Value of 1.0 for Bioaccumulation Factor

This may be an overestimate or underestimate, depending on the chemical, the medium, and the trophic level under consideration.

5.6 Assumptions Regarding Conversion of Literature-Based Toxicity Data into Toxicity Reference Values

A significant degree of subjectivity and uncertainty is involved with this process, particularly when short-term studies or lethal endpoints are involved. The degree to which the assumptions can be considered conservative is dependant upon the chemical under consideration.

5.7 Assumptions Regarding Area Use, Bioavailability, Body Weight, Ingestion Rate, and Other Exposure Factors

In the absence of any USEPA-approved information to the contrary, the most conservative assumptions were adopted across the board for these factors, leading to a highly conservative estimate of the potential for exposure.

5.8 Assumptions Regarding Potential Additive and Synergistic Effects

The response of an organism to combinations of toxicants may be increased or decreased because of toxicological responses at the site of action. These responses may be “additive” – the combined effect of two chemicals is equal to the sum of each individual agent (for example, 2 + 2 = 4), or synergistic – the combined effects of two chemicals is far greater than the sum of the effects of each agent alone (for example 2 + 2 = 40). Because these types of responses are difficult to quantify in a non-laboratory setting, they are generally not evaluated in an ecological risk assessment. Therefore, the conclusions drawn herein may be underestimates of actual biological responses.

5.9 Use of the Lowest Reported Benchmark for Comparison

These values can sometimes vary over orders of magnitude for the same COPC (e.g., arsenic in surface water, fluoranthene in sediment). Selecting the lowest value would tend to increase conservatism.

5.10 Data Limitations

For certain areas and media, data were available for a limited set of analytes, and for a limited sample size (i.e., generally less than 10). In some cases, only inorganic analyses were available (e.g., surface water) or radionuclide analyses were not conducted (e.g., Kress Creek surface water). Data were collected over different time frames for some portions of the study area and combined with data from earlier investigations.

5.10.1 Specific Limitations of the RAD-BCG Model

The evaluation of radionuclide effects on aquatic systems using the RAD-BCG model proceeds through an analysis of both sediment and surface water components. In the absence of one of the two parts, the model calculates these values based on established physicochemical characteristics for the radionuclides of concern. However, actual media concentrations of radionuclides in sediments or surface water may be higher or lower than those predicted by the model, and therefore the eventual screen may not be wholly indicative of actual site conditions.

Additionally, not all detected radionuclides could be screened using the RAD-BCG model because some constituents have not been adequately tested for toxicity in wildlife receptors. As a result, some constituents could create deleterious effects that may be unevaluated.

SECTION 6

Conclusions

Radionuclides and chemical contaminants, at concentrations high enough to potentially adversely affect ecological receptors, have impacted sediments, surface water, and soils at the KCK and STP Sites. For each area of concern and each complete pathway identified, the analytical data were evaluated to determine the potential for ecological risk. Finally, a determination was made as to whether:

1. Risks are acceptable
2. Risks are unacceptable (i.e., calculated HQs were greater than 1) and require immediate mitigation
3. Risks are equivocal and require further investigation

In general, based on the SERA results, it cannot be concluded that there is acceptable risk, and therefore, further investigation would be required to determine the actual risk.

The following sections discuss the conclusions of the SERA for the KCK and STP sites.

6.1 Kress Creek

6.1.1 Radionuclides

The potential for adverse ecological effects in KCK sediments appears to be associated with maximum and mean detections of radionuclides, primarily Ra-226 and Ra-228, the daughter products of uranium and thorium decomposition, respectively. The potential for effects associated with radionuclides may be underestimated due to the unavailability of benchmarks for some radioisotopes that were detected in sediments but not evaluated with the RAD-BCG model.

6.1.2 Chemical Contaminants

Copper, lead, mercury, chrysene, and pyrene are the most important chemical COPCs. While the target HQ of 1.0 for wildlife receptors was exceeded for other metals, PAHs, and Aroclor 1260, these exceedences appear to be minor and may be mitigated by the conservatism inherent in the screening analysis.

The HQs estimated for surface water indicate that few analytes occur at levels sufficient to warrant their inclusion as COPCs, and that exceedences of target HQ values are very slight.

6.2 Sewage Treatment Plant River

6.2.1 Radionuclides

Radionuclide concentrations were markedly lower in sediments from the STP river as compared to KCK, with only Ra-228 demonstrating a HI greater than target risk of 1.0. Concentrations of the uranium isotopes and Ra-226 did not exceed BCGs. Mean concentrations of radionuclides appear to be protective of sensitive wildlife species.

6.2.2 Chemical Contaminants

In general, chemical constituent concentrations in sediments and surface water associated with the STP river were very similar to those in KCK media, except for mercury, which was almost twice that of KCK. Therefore, the list of inorganic and organic COPCs, and those with the potential to affect ecological risk to upper trophic level receptors, was also similar.

Barium appeared to be the dominant constituent of concern in STP river water samples; other inorganic constituents demonstrated slight exceedences, and radionuclide concentrations were low in general. Therefore, risks from sediments and surface water from the STP should be considered lower than those from KCK.

6.3 Sewage Treatment Plant Upland

6.3.1 Radionuclides

Although concentrations of Ra-228 and Th-232 were half those of KCK sediments, these two radionuclides have greater ecological effects on terrestrial mammals than on aquatic receptors, and as a result, have higher partial fractions relative to screening benchmarks. The mean concentrations of radionuclides are significantly lower and do not result in a total sum of fractions greater than 1.0. Therefore, the mean concentrations can be considered protective of sensitive receptors.

6.3.2 Chemical Contaminants

Concentrations of lead and mercury were significant in surface soils collected near the STP. As a result, these two constituents demonstrated high bioaccumulation (and high exceedences of benchmarks) in terrestrial receptors, primarily those that feed on invertebrate prey. It should be noted, however, that the inherent conservatism of the ERA paradigm requires an evaluation of the “worst case scenario” for the site.

6.4 Discussion

These quantitative results should also be considered in the context of the qualitative characterization of habitat quality and the occurrence of other stressors within the study area. As noted above, high quality aquatic and riparian habitat is generally limited to the lower reaches of the study area. Additional stressors related to residential and commercial development within and in close proximity to the study area in the upper reaches may contribute to the relatively poor habitat quality in those areas and may be responsible for the chemical constituents seen in media samples collected in Kress Creek. These locations generally coincide with the occurrence of both radionuclide and chemical COPCs at levels that significantly exceed ecologically-based benchmarks, indicating the potential for adverse effects. The combination of effects potentially associated with the COPCs and those associated with radiological stressors may further increase the possibilities of adverse impacts to ecological receptors in the upper reaches of the Kress Creek system and as a result, remedial activities should focus on the mitigation of these sediments. The proposed cleanup standard of 7.2 pCi/g for combined radium-226 and radium-228 is protective of biota when compared to the toxicological thresholds used here to calculate risk (e.g., BCGs for uranium and Ra-226 and Ra-228 are 2000 pCi/g (U-238); 100 pCi/g and 90 pCi/g, respectively).

SECTION 7

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